ARIZONA STATE UNIVERSITY
PROPOSAL TO ESTABLISH A NEW UNDERGRADUATE DEGREE

This template is to be used only by programs that have received specific written approval from the Provost's office to proceed with internal proposal development and review. A separate proposal must be submitted for each individual new degree program.

DEGREE PROGRAM INFORMATION
College/School(s) offering this degree: Ira A. Fulton School of Engineering

Unit(s) within college/school responsible for program: School of Computing and Informatics/Department of Biomedical Informatics

If this is for an official joint degree program, list all units and colleges/schools that will be involved in offering the degree program and providing the necessary resources: NA

Proposed Degree Name: B.S. in Biomedical Informatics

Undergraduate Degree Type: Bachelor of Science
If Degree Type is Other, provide proposed degree type: 
and proposed abbreviation: NA

Proposed title of major: Biomedical Informatics

Is a program fee required? No

Requested effective term: Fall, 2009
(The first semester and year for which students may begin applying to the program.)

PROPOSAL CONTACT INFORMATION
(Person to contact regarding this proposal)

Name: Carol Behl/Trevor Cohen Title: Asst. Director/Faculty

Phone: 5-8244/602-827-2530 email: cbehl@asu.edu/trevor.cohen@asu.edu

DEAN APPROVAL

This proposal has been approved by all necessary unit and College/School levels of review, and the College/School(s) has the resources to offer this degree program. (Note: An electronic signature, an email from the dean or dean's designee, or a PDF of the signed signature page is acceptable.)

College Dean name: Deirdre R. Meldrum, PhD

College Dean signature ____________________________ Date: __________

College Dean name:
(If more than one college involved)
College Dean signature ____________________________ Date: __________
ARIZONA STATE UNIVERSITY
PROPOSAL TO ESTABLISH A NEW UNDERGRADUATE DEGREE

This proposal template should be completed in full and submitted to the University Provost’s Academic Council [mailto:curriculum@asu.edu]. It must undergo all internal university review and approval steps including those at the unit, college, and university levels. A program may not be implemented until the Provost’s Office notifies the academic unit that the program may be offered.

DEGREE PROGRAM INFORMATION

Undergraduate: BS – Bachelor of Science

Proposed title of major: Biomedical Informatics

1. PURPOSE AND NATURE OF PROGRAM

   1. Brief program description (This is a catalog type description of no more than 250 words. Include the distinctive features of the program that make it unique. Do not include program or admission requirements.)

   Biomedical science, health care delivery, and public health all increasingly rely on multidisciplinary expertise, many diverse sources of data, and complex interactions and collaborations to perform their tasks. The role of biomedical informatics, the field in which computer science, information technology, probabilistic reasoning, cognitive science, and other quantitative and technical methods and skills are applied to biomedicine and health care delivery, is increasingly recognized as essential for progress. Further, it is apparent that we must do a much better job of integrating knowledge and people if excellent health care and biomedical research are to prevail.

   The job market is rapidly expanding for people with such integrative skills, playing both technical and management roles in many biomedical and health care organizations. There is growing demand for such expertise, yet undergraduate and graduate programs have not kept up with demand.

   The proposed program will educate undergraduate students in the informatics knowledge and skills that will enable them (a) to be effective contributors to the informatics aspects of biomedical sciences, technology development, health care delivery, and business sectors related to commercialization of the above; or (b) to be prepared to enter graduate programs in biomedical informatics to equip them to assume leadership positions in these fields.

2. STUDENT LEARNING OUTCOMES AND ASSESSMENT

   1. List the knowledge, competencies, and skills students should have when they graduate from the proposed degree program. (You can find examples of program Learning Outcomes at [http://www.asu.edu/oue/assessment.html](http://www.asu.edu/oue/assessment.html))

1. Identify and appraise current applications of informatics in health sciences and health care delivery systems.
   - Clinical information systems (includes telemedicine)
   - Biological information systems (includes Bioinformatics, Pharmaceutical informatics, and Computational Biology)
   - Imaging systems
   - Population health information systems (includes consumer health systems)
- Health care management and reimbursement systems
- Medical education and evaluation systems including simulation-based tools

2. Evaluate, select, and deploy informatics solutions in health care sciences and health care delivery systems.
   - Describe the processes of needs assessment and selection procedures for informatics systems.
   - Describe common organizational roles and issues related to the implementation of health care delivery systems.
   - Relate financing and contracting issues related to the implementation of health care delivery systems.
   - Describe workflows in clinical and research environments.
   - Utilize different design instruments that aid in describing systems (includes use-case scenarios, UML diagrams, class diagrams)
   - Be able to apply methods for the evaluation of informatics tools, and meaningfully interpret these results
   - Demonstrate an understanding of work flow, and the cognitive aspects of successful system integration

3. Effectively manage biomedical data.
   - Conceive and implement effective data models in a relational database system including biological databases (understanding of normalization, indexing, etc.).
   - Use Structured Query Language to create, manage and interrogate relational databases.
   - Demonstrate a working knowledge of database security issues from the perspectives of database and network administration and of ubiquitous protocols for internetworking and data transport as well as relevant issues of security and privacy.
   - Utilize the XML framework for data markup and applications of XML in the interchange of data among systems; the ability to structure and validate well-formed XML documents.
   - Query remote information systems via web services or other protocols and to ingest data into a local file or data management system.
   - Distinguish types of metadata and familiarity with standards for discipline-specific metadata standards

4. Acquire, convert, and organize biomedical data into relevant diagnostic, therapeutic, or research information.
   - Biological data acquisition and digitalization
   - Imaging data acquisition
   - Organization and reporting of data results
   - Information extraction and data mining tools and techniques
   - Knowledge representation and reasoning
   - Machine learning (includes simulation, modeling of biological systems, mathematical modeling, and data clustering)

5. Demonstrate skills in team dynamics, communication, and project management.
   - Ability to function in an interdisciplinary team environment
   - Demonstrate proficiency in commonly used project management techniques and tools (includes project planning and risk assessment and planning)
   - Technical writing and speech

6. Identify, appraise and utilize biomedical informatics standards and lexicons.
   - Ontologies and standards: what are they and why are they needed
   - Controlled medical vocabularies (includes the UMLS, the Standardized Nomenclature of Medicine, Clinical Term (SNOMED-CT, CD-9, CPT), Logical Observation Identifiers Names and Codes (LOINC) or OpenGALEN Common Reference Model, GO and other bioinformatics ontologies
- Electronic Health Record standards (DICOM, HL7, ASTM, ANSI X12, ISO, TC215)

7. Relate key legal and ethical issues biomedical informatics.
   - Demonstrate a thorough understanding of HIPAA and other privacy related issues
   - Demonstrate the ability to recognize and address ethical or legal implications of informatics applications
   - Demonstrate the ability to recognize and address ethical and legal aspects of software usage and development
   - Review legal and ethical issues related to biomedical research (includes stem cell research, animal research, rare disease drug development, etc.)
   - Discuss issues related to intellectual property (includes patents)

8. Use quantitative and qualitative tools for decision support and data analysis.
   - Clinical study design, study proposal development, and experimental design and statistics (includes sampling, survey design, and analysis and population and demographic data for clinical trials
   - Statistical and probabilistic methods
   - Guideline development and application/evidence based medicine
   - Clinical decision making/application of quantitative and qualitative tools

9. Develop software systems to support informatics applications
   - Command of a procedural programming language
   - Generate code conforming to object-oriented design
   - Generate robust code from project specifications
   - Demonstrate sound programming practice: commenting, unit testing, awareness of space and time complexity

2. **Describe the plan and methods to assess** whether students have achieved the knowledge, competencies and skills identified in the Learning Outcomes. (You can find examples of assessment methods at [http://www.asu.edu/oue/assessment.htm](http://www.asu.edu/oue/assessment.htm))

**Course reviews**: Each learning outcome above will be mapped to a series of courses and activities identified in each of the courses that best demonstrate proficiency of that outcome. Each semester, faculty will conduct, record, and analyze the data to create and implement continuous course improvement.

**Student surveys**: Each semester the Ira A. Fulton School administers surveys to students to evaluate their courses and instructors. We are planning on supplementing these surveys with semester surveys of our own that will most likely be administered in a core sequence courses.

**Employer surveys**: The department will regularly interview employers to make sure that the program objectives are meeting industry standards. This can be done at meetings of our industry advisory council as well as through online methods. We will also interview employers after the first group of students complete their internships in the first semester of their senior year and then again after graduation and placement.

**Alumni surveys**: These will be conducted regularly once we have a graduating class and students have been in the workforce for a year or two.

3. **CURRICULUM OF THE PROPOSED PROGRAM**
   Total credit hours must be 120 to include: first year composition, general studies, core/required courses, program specific electives, and any additional requirements.

1. **Major Map** Please prepare and attach a Major Map. If there are concentrations in this degree program, prepare a separate Major Map for each one. (Examples of Major Maps can be found at [http://provost.asu.edu/curriculum](http://provost.asu.edu/curriculum)
See attached/Appendix A

2. **Total credit hours required for this program:** 120

3. **Core/Required Courses.**
   i. Total required and/or core course credit hours: 95
   ii. List the name, prefix, and credit hours for each required/core class for this program

See attached/Appendix B

4. **Program Specific Electives.** *
   i. Total required program elective credit hours: 10
   ii. List the name, prefix, and credit hours for any program specific electives for this program:

This is a partial list of potential electives

- BIO 355 Introduction to Computational Molecular Biology (3)
- BIO 455/BMI 465 Introduction to Comparative Genetics (3)
- BIO 456/BMI 466 Bioinformatics and Molecular Evolution (3)
- CSE 471 Introduction to Artificial Intelligence (3)
- CSE 414 Advanced Database Concepts (3)
- CSE 459 Logic for Computer Scientists (3)
- CSE 494 Cognitive Systems and Intelligent Agents (3)
- CSE 467 Data and Information Security (3)
- CSE 463 Introduction to Human Computer Interaction (3)
- CSE 465 Introduction to Information Assurance (3)
- CSE 476 Introduction to Natural Language Processing (3)
- STP 420 Introductory Applied Statistics (3)
- Any other related course that would support the student's program

Students preparing for medical school will be allowed to use pre-med course requirements as elective hours. A partial list follows:

- CHM 116
- PHY 111/113
- PHY 112/114
- MAT 265
- CHM 233/237
- CHM 234/236

*All electives must be chosen in conjunction with the student advisor*

5. **Additional Program Requirements, if any.** List and describe any capstone experiences, milestone, and/or additional requirements for this degree program:

**Internship (3)** Each student will be required to earn three academic hours of internship credit to be applied to the graduation requirements of 120 credits. The department faculty and program coordinator will place students in a real-world work experience where they can apply their knowledge of biomedical informatics
Capstone (6) Each student will participate in an individual research and a team capstone project. These projects will be chosen in conjunction with their faculty advisors. (Barrett Honor’s College students will do an honor’s thesis in lieu of the individual research capstone project.)

6. Are any concentrations to be established under this degree program? No

4. NEW COURSE DEVELOPMENT
A. Will a new course prefix(es) be required for this degree program? No
   If yes, complete the request for establishment of a new prefix for each prefix and submit with this proposal.

B. New Courses Required for Proposed Degree Program. List all new courses required for this program, including course prefix, number and course description.

BMI 101 Introduction to Biomedical Informatics I
   Introduction to existing and future applications of biomedical informatics. Overview of history and present state of the field. Introduction to topics in translational bioinformatics, such as sequence alignment, the Human Genome Project, gene expression analysis, genome wide association studies, next generation sequencing.

BMI 102 Introduction to Biomedical Informatics II
   Introduction to existing and future applications of biomedical informatics. Overview of history and present state of the field. This is the second course in a three semester series which focuses on biomedical informatics applications in public health (such as population studies and outbreak detection) and medical imaging, including telemedicine.

BMI 201 Introduction to Biomedical Informatics III
   Introduction to existing and future applications of biomedical informatics. Overview of history and present state of the field. This third course in the series provides an introduction to biomedical informatics techniques and applications used in clinical environments. This includes searching and organizing free text information, decision analysis techniques and clinical decision support systems, and clinical applications including physician order entry used in electronic medical records. Course also covers challenges in clinical informatics, including sociotechnical and cognitive issues in implementation and use.

BMI 211 Biomedical Informatics Methods I
   The first semester of a three semester course sequence surveying the methods and theories underlying the field of biomedical informatics. This segment of the course explores models of medical decision making including classical decision theory, Bayesian and cognitive models. The course will also include a component discussing evaluation methods in biomedical informatics.

BMI 221 Knowledge Representation for Biomedical Informatics
   Introduction to topics in knowledge representation and modeling, including frame-based systems, logic-based systems, rule-based systems, inference, and reasoning. Overview of history and present state of the field.

BMI 301 Introduction to Clinical Environments
   This three-credit course is designed for medical informatics students who have no significant clinical experience in the U.S. The course will introduce medical terminology and expose students to the clinical environments in which health care providers create, manage, and use clinical information. Students will be expected to attend lectures and will spend a significant portion of their time examining and reporting on different clinical settings throughout the semester.

BMI 311 Biomedical Informatics Methods II
This course introduces concepts of artificial intelligence and knowledge modeling using medical informatics examples. Students will understand the historical foundations and motivations of AI in medical applications, learn how problem-solving, reasoning, knowledge management, and planning can be applied to medical informatics problems.

BMI 312 Biomedical Informatics Methods III
The third semester of a three semester course surveying the methods and theories underlying the field of biomedical informatics. This course explores methods of use in the design and maintenance of biomedical databases, machine learning techniques, information retrieval in biomedicine and methods specific to bioinformatics.

BMI 330 Topics in Translational Bioinformatics
The course will provide an introduction to bioinformatics methods and applications used in the field of translational medicine research. Topics will include bioinformatics data acquisition and management (e.g., microarrays, database modeling and integration), analysis methodologies (e.g., statistics, data mining) and applications.

BMI 332 Team Dynamics for Healthcare IT Projects
This course teaches the fundamentals of leadership, management, and team dynamics in a project-focused software engineering environment, and with a focus on informatics and healthcare applications. The course will teach students about team and group dynamics, recognizing dysfunctional teams, and helping to fostering productive group and leadership skills.

BMI 461 Advanced Topics in Biomedical Informatics I
This course covers current trends and cutting edge research areas of clinical, public health and consumer health informatics. The course has a particular emphasis on research that is of relevance to patients, and the healthy public, covering such topics as outbreak detection and the personal health record. In addition, it will cover research on the use of technology in medical education, and the ways in which clinical decision support systems are applied in contemporary medical practice.

BMI 462 Advanced Topics in Biomedical Informatics II
This course covers current trends and cutting edge research areas of bioinformatics, imaging informatics and translational science. The emphasis of this course is on informatics approaches to novel data sources that are supplied by the next generation of methods for affordable gene sequencing, and initiatives underway to accelerate the integration of novel research findings into everyday clinical practice. Includes a series on modeling and simulation, current approaches to computer-aided diagnosis of medical images, ways in which technology can support the discovery of new knowledge, and the application of telemedicine to facilitate clinical care remotely.

BMI 482 Capstone I
First course in capstone sequence for biomedical informatics majors emphasizing the development of technical skills and effective team work within the context of a research project in biomedical informatics.

BMI 483 Capstone II
Second course in capstone sequence for biomedical informatics majors emphasizing the development of technical skills and effective team work within the context of an applied project in biomedical informatics.

5. PROGRAM NEED. Explain why the university needs to offer this program (include target audience and market).

Biomedical Informatics refers to the development and application of methods for acquiring, representing, retrieving and analyzing biomedical data and knowledge. Students entering this field will require preparation that integrates technological expertise in informatics, computer sciences, biosciences and mathematical statistics with knowledge of the biomedical science research.
environment, clinical environment in the healthcare professions, and the community and public health aspects of health maintenance, disease prevention, and health care. An extensive search of institutions of higher learning in the United States found no other accredited universities offering a four-year degree in this unique field. While one or two schools, such as the Rochester Institute of Technology, offer related programs in Medical Informatics, most focus on the technological applications neglecting the life sciences and study of clinical environments. This proposed program will help students focus their studies of biology and computer science in domain-specific situations including the health care system and research laboratories. No one existing degree program at ASU meets that need. "Many grads from excellent programs seem to have very little practical education or experience to be helpful in real world applied informatics," says R. Taryien, Chief Medical Information Officer at CHW/St. Joseph's Hospital.

The graduates from our M.S. and Ph.D. programs in Biomedical Informatics will be able to conceptualize and design novel informatics methods and applications while the B.S. students will be working to apply those methods in health care facilities. The B.S. in Biomedical Informatics will produce graduates who will contribute to the workforce in Phoenix, Arizona as well as nation-wide. In a survey conducted by the department, current valley employers reported need for at over 200 biomedical informaticians at the Bachelor's level over the next five years in such job titles as Clinical Informatics Specialist, Decision Support Analyst, Program Research Analyst, Encounter Data Analyst, Health Plan Performance Analyst, Program Evaluator, Quality Improvement Analyst, and Population Health Analyst. Actuarial Services Analyst, and Actuarial Services Manager. We can extrapolate to the national market in clinical informatics, exemplified by the American Medical Informatics Association's 10x10 campaign, seeking to meet the need for 10,000 individuals trained in clinical informatics by the year 2010. In biosciences, similarly, there are many expanding career opportunities. (See Appendix C for survey results)

Students with a wide range of interests will be attracted to this program. Some may see this program as a unique way to combine their interest in life sciences and technology. Others may find this degree the first step toward medical school or advanced medical research or to continued graduate-level study in biomedical informatics. Students who enter this program will also be strongly encouraged to apply for acceptance to the Barrett Honor's College. The faculty in the Department of Biomedical Informatics will work closely with the honor's college to recruit, admit, and graduate students from this program.

6. IMPACT ON OTHER PROGRAMS. List other academic units that might be impacted by the proposed program and describe the potential impact (e.g., how the implementation of this program might affect student headcount/enrollment, student recruitment, faculty participation, course content, etc. in other programs).

School of Life Sciences
Computer Science and Engineering
Barrett Honor's College

While we are requiring three courses in Biology and six in Computer Science, there should be little impact on enrollment for those departments as we anticipate a cohort of only 25 students each Fall. BMI faculty are currently working with those departments to ensure that our students will be accommodated.

Student recruitment will be done by the School of Computing and Informatics in conjunction with Barrett Honor's College.

The content of the newly created Biomedical Informatics courses does not duplicate course content in other departments. BMI faculty will continue to work closely with administration from the School of
Life Sciences as well as from the Department of Computer Science as they implement a program that remains complimentary without having significant overlap.

(See Appendix D for letters of support)

7. **PROJECTED ENROLLMENT** How many new students do you anticipate enrolling in this program each year for the next five years? Please utilize the following tabular format.

<table>
<thead>
<tr>
<th>5-YEAR PROJECTED ANNUAL ENROLLMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td><strong>1st Year</strong></td>
</tr>
<tr>
<td>(Yr 1 continuing + new entering)</td>
</tr>
<tr>
<td>Number of Students Majoring (Headcount)</td>
</tr>
<tr>
<td><strong>2nd Year</strong></td>
</tr>
<tr>
<td>(Yr 1 &amp; 2 continuing + new entering)</td>
</tr>
<tr>
<td><strong>3rd Year</strong></td>
</tr>
<tr>
<td>(Yrs 1, 2, 3 continuing + new entering)</td>
</tr>
<tr>
<td><strong>4th Year</strong></td>
</tr>
<tr>
<td>(Yrs 1, 2, 3, 4 continuing + new entering)</td>
</tr>
<tr>
<td><strong>5th Year</strong></td>
</tr>
<tr>
<td>(Yrs 1, 2, 3, 4, 5 continuing + new entering)</td>
</tr>
</tbody>
</table>

8. **ACCREDITATION OR LICENSING REQUIREMENTS** (if applicable). Provide the names of the external agencies for accreditation, professional licensing, etc. that guide your curriculum for this program, if any. Describe any requirements for accreditation or licensing.

NA

9. **FACULTY and STAFF**
   a. **Current Faculty**. List the name, rank, highest degree, area of specialization/expertise and estimate of the level of involvement of all current faculty who will teach in the program.

   Robert Greenes, Chair, M.D., Ph.D. 5%
   Virnila Patel, Ph.D., D.Sc. 10%
   Doug Fridesma, M.D., Ph.D. 10%
   Trevor Cohen, M.D., Ph.D. 10%
   Valentin Dinu, Ph.D. 10%
   Kanav Kahol, Ph.D. 10%
   Graciela Gonzales, Ph.D. 10%
   Diana Petitti, M.D. 10%
   William Johnson, Ph.D. 10%
   Jianming Liang, Ph.D. 10%

   Clinical Decision Support and Imaging Informatics
   Cognitive Science in Informatics, Decision Making and Medical Errors
   Ontologies and Standards, Controlled Medical Vocabularies, Semantic Interoperability, Clinical Research Cognition, Distributional Semantics, Natural Language Processing, Medical Errors
   Bioinformatics, Data Mining, Statistical Analysis, Database Modeling
   Haptic Interfaces, Simulation for medical education, Ubiquitous Data Collection
   Text mining, Knowledge Discovery, Databases, Software Engineering
   Population Informatics, Epidemiology, Data Mining, Public Health Informatics
   Population Health, Predictive Modeling, Disease Surveillance
   Imaging Informatics, Computer-Aided Diagnosis
b. **New Faculty.** Describe the new faculty hiring needed during the next three years to sustain the program and list the anticipated hiring schedule for addition of these faculty.

The Biomedical Informatics Department is currently hiring five new faculty for the 2008-2009 academic school year. This will bring the total number of faculty to fifteen. We have calculated that these fifteen faculty can adequately handle the new BMI courses for the undergraduate program.

c. **Administration of the program.** Explain how the program will be administered for the purposes of admissions, advising, course offerings, etc. Discuss the available staff support.

All students will be admitted by the university using standard Ira A. Fulton School of Engineering standards. Students will then apply separately to Barrett Honor's College for admission.

The SCI advisors along with a specially designator BMI faculty director and program coordinator (to be hired) will do all student advising. The BMI faculty director and the undergraduate program coordinator will also oversee all student internship experiences.

The SCI assistant director for academic programs will administer all course offerings in conjunction with the Chair of the department and the faculty director. The assistant director will let the chair know which courses should be taught and the chair will assign faculty to teach. The undergraduate program coordinator will notify students of course offerings including all available elective courses. Courses will be offered in a Fall/Spring only format as indicated on the attached major map.

10. **RESOURCES (necessary to launch and sustain the program)**

   a. Describe any new resources required for this program's success, such as new support staff, new facilities, new library resources, new technology resources, etc.

New classroom buildings for the downtown campus are currently being planned. The department is working with the architects and the university so that the needs of this new program will be accommodated both in classroom and in lab space. The classroom and labs require various levels of mediation.

Two new staff lines are necessary to run this new program. One position will be that of **program coordinator.** This person will oversee most of the student advising, all internship placements, and student event planning including all retention and recruitment events. This person will also coordinate with Barrett Honor's College to insure that students are meeting those requirements. The second position will be an **administrative assistant.** This person will answer queries, process student paperwork, help to set up events, and give support to the program coordinator as well as to the faculty director.

b. Explain where you will get the resources to support this program.

The building funding is already approved. The resources for two new staff will not be needed until Fall, 2010 when we anticipate receiving this extra funding. No other resources are necessary.
## Appendix A
### Major Map
#### Major Map: Biomedical Informatics – Bachelor of Science (B.S.)

<table>
<thead>
<tr>
<th>Course Subject and Title</th>
<th>Hrs</th>
<th>Upper Division</th>
<th>Grading Option</th>
<th>Minimum Grade Required</th>
<th>Additional Critical Requirement Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TERM ONE: 6-15 CREDIT HOURS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASU 101: The ASU Experience</td>
<td>1</td>
<td></td>
<td></td>
<td>Grade of B</td>
<td></td>
</tr>
<tr>
<td>@BMI 101: Introduction to Biomedical Informatics</td>
<td>3</td>
<td></td>
<td></td>
<td>Grade of B</td>
<td>- Complete BMI 101 with a minimum grade of “B”</td>
</tr>
<tr>
<td>CHM 113: General Chemistry I (SQ)</td>
<td>4</td>
<td></td>
<td></td>
<td>Grade of C</td>
<td>- Complete CHM 113, ENG 101 and BMI 101 with a minimum grade of “B”</td>
</tr>
<tr>
<td>ENG 101 or 102: Freshman Composition OR</td>
<td>3</td>
<td></td>
<td></td>
<td>Grade of C</td>
<td></td>
</tr>
<tr>
<td>ENG 103: Advanced Freshman Composition OR</td>
<td>3</td>
<td></td>
<td></td>
<td>Grade of C</td>
<td></td>
</tr>
<tr>
<td>ENG 107 or 108: English for Foreign Students</td>
<td>3</td>
<td></td>
<td></td>
<td>Grade of C</td>
<td></td>
</tr>
<tr>
<td>Social &amp; Behavioral Science (SB) AND Cultural Diversity in the US (G) Global Awareness (G) or Historical Awareness (H)</td>
<td>3</td>
<td></td>
<td></td>
<td>Grade of C</td>
<td></td>
</tr>
<tr>
<td><strong>TERM TWO: 16-30 CREDIT HOURS</strong></td>
<td></td>
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<tr>
<td>ENG 101 or 102: Freshman Composition OR</td>
<td>3</td>
<td></td>
<td></td>
<td>Grade of C</td>
<td></td>
</tr>
<tr>
<td>ENG 103: Advanced Freshman Composition OR</td>
<td>3</td>
<td></td>
<td></td>
<td>Grade of C</td>
<td></td>
</tr>
<tr>
<td>ENG 107 or 108: English for Foreign Students</td>
<td>3</td>
<td></td>
<td></td>
<td>Grade of C</td>
<td></td>
</tr>
<tr>
<td>@BMI 101: Introduction to Biomedical Informatics</td>
<td>3</td>
<td></td>
<td></td>
<td>Grade of B</td>
<td>- Complete BMI 101 with a minimum grade of “B”</td>
</tr>
<tr>
<td>BIO 188: General Biology I (SQ)</td>
<td>4</td>
<td></td>
<td></td>
<td>Grade of B</td>
<td>- Complete First Year Composition Requirement: ENG 101 &amp; 102 OR ENG 107 &amp; 108 OR ENG 115.</td>
</tr>
<tr>
<td>@BMI 101: Introduction to Biomedical Informatics</td>
<td>3</td>
<td></td>
<td></td>
<td>Grade of B</td>
<td>- Complete BMI 101 with a minimum grade of “B”</td>
</tr>
<tr>
<td>CSE 110: Principles of Programming with Java (C++)</td>
<td>3</td>
<td></td>
<td></td>
<td>Grade of B</td>
<td>- Complete CHM 113, ENG 101 and BMI 101 with a minimum grade of “B”</td>
</tr>
<tr>
<td>CP 200: Mathematical Foundations of Information (MA)</td>
<td>3</td>
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<td>Grade of B</td>
<td>- Complete CHM 113, ENG 101 and BMI 101 with a minimum grade of “B”</td>
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<tr>
<td><strong>TERM THREE: 41-48 CREDIT HOURS</strong></td>
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<tr>
<td>ETP 226: Elements of Statistics</td>
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<td>Grade of B</td>
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<tr>
<td>BIO 187: General Biology I (SQ)</td>
<td>4</td>
<td></td>
<td></td>
<td>Grade of B</td>
<td>- Complete First Year Composition Requirement: ENG 101 &amp; 102 OR ENG 107 &amp; 108 OR ENG 115.</td>
</tr>
<tr>
<td>@BMI 201: Introduction to Biomedical Informatics</td>
<td>3</td>
<td></td>
<td></td>
<td>Grade of B</td>
<td>- Complete BMI 201 with a minimum grade of “B”</td>
</tr>
<tr>
<td>CSE 205: Object-Oriented Programming and Data Structures</td>
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<td>HSM 212: Health Care Organizations</td>
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<tr>
<td><strong>TERM FOUR: 46-60 CREDIT HOURS</strong></td>
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<tr>
<td>@BMI 240: Genetics</td>
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<td></td>
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<td>- Complete BMI 240, BMI 340, BMI 211 and BMI 211 each with a minimum grade of “B”</td>
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<tr>
<td>@BMI 311: Biomedical Informatics Methods I</td>
<td>3</td>
<td></td>
<td></td>
<td>Grade of B</td>
<td>- Complete First Year Composition Requirement: ENG 101 &amp; 102 OR ENG 107 &amp; 108 OR ENG 115.</td>
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<tr>
<td>@BMI 321: Knowledge Representation for Biomedical Informatics</td>
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<td></td>
<td>Grade of B</td>
<td>- Complete First Year Composition Requirement: ENG 101 &amp; 102 OR ENG 107 &amp; 108 OR ENG 115.</td>
</tr>
<tr>
<td>CSE 340: Introduction to Programming Languages</td>
<td>3</td>
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<td></td>
<td>Grade of B</td>
<td>- Complete CHM 113, ENG 101 and BMI 101 with a minimum grade of “B”</td>
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<td>Social &amp; Behavioral Science (SB) AND Cultural Diversity in the US (G) Global Awareness (G) or Historical Awareness (H)</td>
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<td>@BMI 321: Knowledge Representation for Biomedical Informatics</td>
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<td>- Complete Upper Division Major Course: A minimum cumulative GPA of 3.0 required</td>
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<tr>
<td>@BMI 330: Topics in Translational Biotechnology</td>
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<td><strong>TERM SEVEN: 91-106 CREDIT HOURS</strong></td>
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<td>BMI 461: Advanced Topics in Biomedical Informatics</td>
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<tr>
<td>BMI 491: Internship</td>
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<td>@BMI 483: Capstone II (proposed Literacy)</td>
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<td></td>
<td>Grade of C</td>
<td>- Complete BMI 491, BMI 491, BMI 491 and BMI 491 each with a minimum grade of “B”</td>
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</table>

- If Technical Electives are selected, a total of 6-11 credit hours are required.
- Additional critical requirements may apply based on advisor approval.

11
Appendix B
Core/Required Courses

<table>
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<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>1st Semester</td>
<td>ASU 101 (1)</td>
<td>The Freshmen Year Experience</td>
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<tr>
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<td>ENG 101/105 (3)</td>
<td>Freshmen Composition</td>
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<tr>
<td></td>
<td>HON 171 (3)</td>
<td>The Human Event</td>
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<tr>
<td></td>
<td>CHM 113 (4)</td>
<td>General Chemistry I</td>
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<td>BMI 101 (3)</td>
<td>Introduction to Biomedical Informatics I</td>
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<tr>
<td>2nd Semester</td>
<td>ENG 102 (3)</td>
<td>Freshmen Composition</td>
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<td>HON 273 (3)</td>
<td>The Human Event: Science Focus</td>
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<td></td>
<td>CSE 110 (3)</td>
<td>Principles of Programming with Java</td>
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<td></td>
<td>BIO 188 (4)</td>
<td>General Biology II</td>
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<td></td>
<td>CPI 200 (3)</td>
<td>Mathematical Foundations of Informatics</td>
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<td>BMI 102 (3)</td>
<td>Introduction to Biomedical Informatics II</td>
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<td>3rd Semester</td>
<td>STP 225 (3)</td>
<td>Elements of Statistics</td>
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<td>CSE 205 (3)</td>
<td>Object Oriented Programming and Data Structures</td>
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<td>HSM 220 (3)</td>
<td>Health Care Organizations</td>
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<td>BMI 201 (3)</td>
<td>Introduction to Biomedical Informatics III</td>
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<td></td>
<td>BIO 187 (4)</td>
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<td>4th Semester</td>
<td>CSE 240 (3)</td>
<td>Introduction to Programming Languages</td>
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<td>BIO 340 (4)</td>
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<td></td>
<td>BMI 221 (3)</td>
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<td>5th Semester</td>
<td>BMI 301 (3)</td>
<td>Introduction to Clinical Environments</td>
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<td>BMI 311 (3)</td>
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<td>BMI 332 (3)</td>
<td>Team Dynamics for Healthcare IT Projects</td>
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<td>6th Semester</td>
<td>CSE 412 (3)</td>
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<td>BMI 330 (3)</td>
<td>Topics in Translational Bioinformatics</td>
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<td>BMI 312 (3)</td>
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<td>CSE 360 (3)</td>
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<td>7th Semester</td>
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<td>BMI 484 (3)</td>
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<td>BMI 461 (3)</td>
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<td>8th Semester</td>
<td>BMI 483 (3)</td>
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## Appendix C

### Industry Survey

<table>
<thead>
<tr>
<th>Institution</th>
<th>BS</th>
<th>MS</th>
<th>PhD</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>TGen</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>Our most pressing need would be for those whose graduate with Ph.D. Far less for B.S. Clinical Informatician (MS/PhD), Biomedical Informatician (MS/PhD), Bioinformatician (MS/PhD), Computational Scientists (MS/PhD), Scientific Programmer (BS/MS), Scientific Application Developer (BS/MS). Individuals should be able to develop parallel computing, data analysis and visualization tools; should be able to write scientific code using C/C++, Java, Perl, and R; should have some understanding of open-source database technologies, such as MySQL and PostgreSQL; and should be familiar with public genomics/proteomics databases, including standards such as ICD, UMLS, SNOMED, HL7, LOINC, MAGE-ML, etc. Obviously, individuals should know about genomics and proteomics measurement technology platforms and their data formats/properties. Individuals should be able to develop high performance computational/statistical methods and algorithms as well as write their own code without relying upon other programmers.</td>
</tr>
<tr>
<td>CHW/St. Joseph’s</td>
<td>4</td>
<td>1</td>
<td>0.3</td>
<td>Many grads from excellent programs seem to have very little practical education or experience to be helpful in real world applied informatics. Logistics of knowledge management across 10 community hospitals, assessing risk and planning for successful medical staff adoption of CPOE</td>
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<td>Scottsdale Health</td>
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<td>Schaller-Anderson</td>
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<td>0</td>
<td>Actuarial Services Analyst, Actuarial Services Manager</td>
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<td>Indian Health Service</td>
<td>1.5</td>
<td>0.5</td>
<td>0.5</td>
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<tr>
<td>Carefx</td>
<td>15</td>
<td>5</td>
<td>2</td>
<td>BS degree clinical informatics to progress to deployment manager. MS to Deployment Manager for each facility with &gt; 100 beds (and one DM every 4 rural facilities), which gives us a total of 10 plus 4 director level positions at the corporate office - with 25% turnover per year</td>
</tr>
<tr>
<td>Banner Health</td>
<td>10</td>
<td>3.5</td>
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<td>Healthcare</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

As you may know UHC and our parent company UnitedHealthGroup is a broad diverse organization. Our needs transcend just Arizona but nationally and increasingly globally. Most of the graduates from your program would more than likely fit in our Ingenix subsidiary (a company with over 400 separate individual companies underneath it i.e., Reden & Ander's Actuarial Consulting, the Lewin Group, and many technology companies). Across the various companies we need the usual actuarial expertise but increasingly, medical economists, technology evaluation, health information technology, biostatistics and epidemiologist, medical ethicists (relevant to coverage policy and evaluation for DNA/genetic engineered treatment protocol), and pharmacists at all levels.

*refers to estimated numbers of hires from these degree programs each year
Appendix D
Letters of Support

Computer Science and Engineering

To: Robert Greenes, Chair, Department of Biomedical Informatics
From: Chitta Baral, Chair, Department of Computer Science and Engineering

Date: August 26, 2008
RE: Support of an Undergraduate Program in Biomedical Informatics

The Department of Computer Science strongly supports the proposed undergraduate program in Biomedical Informatics. We understand that a cohort of students from this program will be seeking entrance to some of our courses each semester but believe this will have negligible resource implications. We view this program as a complement to our current degree programs but believe it is different enough in scope to limit competition and confusion for students.
School of Life Sciences

12 November 2008

MEMORANDUM

TO: Robert A. Greenes  
Chair, Department of Biomedical Informatics

FROM: Andrew T. Smith  
Associate Director, Undergraduate Programs,  
School of Life Sciences

SUBJECT: Proposal to establish a new undergraduate program: BS in Biomedical Informatics

Per the Proposal to Establish a New Undergraduate Program: BS in Biomedical Informatics (Degree Program Information; Potential Degree Plan, etc.) received 13 August:

The proposed degree plan complements at ASU the existing School of Life Sciences BS Biological Sciences concentration in Genomics and Bioinformatics, but appears to be independent and unique. The SoLS concentration stresses evolutionary approaches to the diversity of life, broadly writ, while the new proposed Biomedical Informatics degree stresses medical/clinical records, etc. There appears to be little overlap between the programs, and I would even doubt that there would be competition for students, despite the similarity in the degree titles. Thus SoLS can support the establishment of this new degree program.

There are, however, several areas where the two units can cooperate with regard to classes offered to our student populations, and we also offer several suggestions with regard to SoLS courses that are mentioned in the Degree Plan, Information packet, and accompanying e-mails).

First, in general, taking majors courses in SoLS requires a background in chemistry. We even recommend that our incoming students postpone taking BIO 187 in the Fall freshman semester (we suggest Spring of their freshman year to begin our year-long introductory sequence) – as measures of success in the course are demonstrably higher when students have been exposed to university chemistry and mathematics first. BMI students will likely survive taking BIO 187/188 w/o chemistry, but that will not necessarily be the case with Genetics (BIO 340) or Genetic Engineering and Society (MBB/BIO 343). Also, the MBB 343 is currently being taught at capacity – and we would not be able to
accommodate additional students without significant new resources — and it is taught in the Fall, whereas it is listed in the Spring semester on the BMI Degree Plan.

What are the best options, given these comments? It does not seem appropriate to have MBB/BIO 343 as a required course in the new BMI major, nor does it seem fitting to list BIO 340. Instead, taking a year of inorganic chemistry (CHM 113/116) in the freshman year, and then maybe our MBB 245/247 sequence rather than our BIO 187/188 sequence, would be best. In this way BMI students would be exposed to applied biosciences, and the chemistry would prepare them for other issues in the field of clinical bioinformatics, such as dealing with MRI data, etc.

The proposed major calls for taking BIO/MBB/MAT 355 Introduction to Computational Molecular Biology. This is an appropriate course for the proposed major, but it is traditionally filled to capacity, and the capacity is limited by our instructional faculty and the need to teach the course in a room with computers for students. Before receiving the proposal for the BMI degree, we were having discussions in SoLS about the problems we face to offer sufficient seats in 355 for our current student population in our MBB degree program and Genomics and Bioinformatics concentration. The only way that this course could be made a requirement in your degree program would be if you could provide a faculty member to teach one section/year (24 students) — and we would still, for both our majors, be at or over the capacity we can offer.

The Degree Program Information sheet and the Degree Plan (which I understand are drafts) list elective courses — 9 credits. But, only three 3-credit courses are listed, making them each mandatory. This is problematic for us, as two of the courses are BIO prefixes (455 and 456) — and we do not offer these courses regularly. They are small-enrollment specialty courses, and as indicated above, highlight a different direction for bioinformatics (more evolutionary) than a clinical one. I understand you plan to offer a broader suite of courses on this elective list — which is essential, as we cannot guarantee these courses reliably to your students as they progress through your program. These courses are cross-listed with a BMI prefix, so again, there is the opportunity for your faculty to participate in the offering of these courses (BMI 465 = BIO 455).

We offer these suggestions to your planning effort, as it is essential to understand what the university can provide (and not provide). SoLS is very sensitive to this, as we have a burgeoning student population and face increased problems in offering our curriculum in a reliable manner. The other issue for the proposed degree is the outcome of taking courses — in which case we would encourage you to consider our comments concerning chemistry and upper division SoLS courses such as BIO 340 and 343.
From: Carol Behl  
Sent: Thursday, September 11, 2008 2:19 PM  
To: Andrew Smith  
Cc: Robert A. Greenes  
Subject: RE: UG Bioinformatics Major

Dear Andrew,

Our Fulton curriculum committee has reviewed our proposal which included your letter of support for our program. As you might remember, we made some changes to our program based on your comments. Could you please take a moment to review the updated proposal and let us know if it satisfies your concerns.

The substantive changes appear in Appendix A/Major Map on page 14 of the document. In short, we added CHM 113 to our list of mandatory courses and withdrew both BIO 343 and BIO 355. We listed BIO 355 as an elective (on page 5) and hope to work with SoLS to offer this course in the future.

Thanks again for your time on this.

Carol Behl, Ph.D.  
Assistant Director, Academic Programs  
School of Computing and Informatics  
Arizona State University  
480-965-8244

---

Dear Carol:

Thanks for sending this along. I appreciate the changes you made, and the proposal looks fine! I think the students (particularly those with pre-health in mind) will appreciate the CHM 113 being on the major map. And we look forward to working with you to define teaching between you, math and SoLS for the MBB/BIO/MAT 355 course that we all are a part of!

Best Wishes,

Andrew

Dr. Andrew T. Smith  
Parents' Association Professor  
Associate Director for Undergraduate Programs  
School of Life Sciences  
Box 874701  
Arizona State University  
Tempe, AZ 85287-4701  
Phone: ++480.965.9537  
a.smith@asu.edu
Curriculum Review Committee  
Ira Fulton School of Engineering  
Arizona State University  

Curriculum review committee,

I am writing in support of the new undergraduate major in Biomedical Informatics, proposed by the Department of Biomedical Informatics in the Ira A Fulton School of Engineering at ASU. This program is carefully designed to provide students with exposure to material from multiple disciplines that are needed to inform their thinking about the fields included in the major. In addition, the program includes sufficient opportunities for Barrett students to complete the necessary 36 honors credits, including the two-semester, first-year Human Event seminar and the honors thesis. We enthusiastically support this proposal and believe it will be an excellent addition to the programs available to undergraduates in your School at ASU.

Sincerely,

[Signature]

Margaret C. Nelson, Vice Dean  
Barrett, the Honors College at ASU
Appendix E
Sample Job Descriptions

Position #1

BANNER HEALTH
POSITION DESCRIPTION

<table>
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<th>POSITION TITLE:</th>
<th>Care Transformation Project</th>
<th>DATE WRITTEN:</th>
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<tbody>
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<td></td>
<td>DATE APPROVED:</td>
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<td>POSITION ID:</td>
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<td>PREPARED BY:</td>
</tr>
<tr>
<td>FACILITY:</td>
<td>Banner Health</td>
<td>STATUS:</td>
</tr>
</tbody>
</table>

SUMMARY:
This position supports realization of benefits resulting from work redesign, cultural change, and development of clinical knowledge and content with the implementation of clinical information systems technology. This position monitors and documents qualitative and quantitative improvements resulting from Care Transformation and identifies and supports resolution of issues. Tracks project risks and risk mitigation activities. Facilitates “hard wiring” of clinical improvements by incorporating clinical standards into redesigned work processes and system implementations.

ESSENTIAL FUNCTIONS:

1. 

2. Works with System Director and CT Director in the planning, preparation and management of the Care Transformation operating and capital budgets.

3. Provides corporate level project management of the Care Transformation initiative.

4. Monitors and measures the qualitative and quantitative improvements achieved throughout the life of the project to support realization of benefits.

5. Participates in the high level monitoring of issues tracking and resolution for Care Transformation system implementations.
6. High level monitoring and tracking of project risks and risk mitigation activities as related to the Care Transformation initiative.

7. Partners with IT and Project Management department and adheres to Project Management methodology.

8. Facilitates, at a high level, the integration of Banner's clinical standards into redesigned work processes, cultural changes and system implementations in order to "hard wire" clinical improvements through the use of technology.

Performs all functions according to established policies, procedures, regulatory and accreditation requirements, as well as applicable professional standards. Provides all customers of Banner Health with an excellent service experience by consistently demonstrating our Performance Standards each and every day. Banner's Performance Standards include: Safety, Attitude, Responsiveness, Communication, Comfort, Privacy, Appearance, Teamwork, and Accountability.

NOTE: The essential functions are intended to describe the general content of and requirements of this position and are not intended to be an exhaustive statement of duties. Specific tasks or responsibilities will be documented in the incumbent's addendum as outlined by the incumbent's immediate manager.

**MARGINAL OR ADDITIONAL FUNCTIONS:**

Performs related work as assigned or needed.

**SUPERVISORY RESPONSIBILITIES:**

**DIRECTLY REPORTING:**

None

**MATRIX OR INDIRECT REPORTING:**

Care Transformation Deployment Managers across the organization

**TYPE OF SUPERVISORY RESPONSIBILITIES:**

Banner Health Leadership will strive to uphold the mission, vision, and values of the organization. They will serve as role models for staff and act in a people-centered, service excellence-focused, and results-oriented manner.

**SCOPE AND COMPLEXITY:**

This position must work collaboratively with a wide variety of clinical, technical and corporate resources to successfully deploy Care Transformation across the organization. The incumbent must exercise sound judgment and independent decision-making. Must
maintain effective communication on project status with various stakeholders.

PHYSICAL DEMANDS/ENVIRONMENT FACTORS:
Requires extensive sitting with periodic standing and walking. No exposure to hazardous or significantly unpleasant conditions anticipated. Typically requires routine use of personal computer and general office equipment. Needs adequate visual acuity, ability to grasp and handle objects, ability to communicate effectively through reading, writing, and speaking in person or on the telephone. May require off-site travel.

EQUIPMENT USED:
Typical office equipment, including personal computer.

MINIMUM QUALIFICATIONS:
Requires Bachelor's of Science degree or equivalent in healthcare, computer science, business or related field. Requires working knowledge of the healthcare environment including clinical, business, technical, legal, and financial aspects typically achieved in five or more years of experience in the healthcare industry. This position requires extensive past experience in project management and demonstrated knowledge of project management methodology. Excellent organizational skills with the ability to handle a variety of leadership, decision making, and facilitation requirements while maintaining flexible, self-managed and detail-oriented activities is required. Excellent oral and written communications in group and individual situations is essential. Needs demonstrated facilitation, problem-solving, critical thinking, and human relations abilities.
To: James Collofello, Associate Dean, Ira A. Fulton School of Engineering

From: Sethuraman Panchanathan, Director, School of Computing and Informatics

Date: August 27, 2008

RE: Proposal for a Bachelor of Science degree in Biomedical Informatics

The faculty of the Department of Biomedical Informatics in the School of Computing and Informatics enthusiastically supports the proposal for a new Bachelor of Science degree in Biomedical Informatics. Please do not hesitate to contact me for more information or clarifications.
September 17, 2008

TO: Elizabeth Capaldi
Executive Vice President and Provost

FROM: James S. Collofello
Associate Dean of Academic Affairs
Ira A. Fulton School of Engineering

RE: Request for Implementation Authorization for a BS degree in Biomedical Informatics

Attached is a proposal from the Biomedical Informatics faculty for the implementation of an undergraduate Bachelor of Science program in Biomedical Informatics in the School of Computing and Informatics. There is a keen interest by industry for students with this degree. The Ira A. Fulton School of Engineering supports this proposal.

The proposal has been reviewed by the School's Curriculum Committee, and they recommend approval. We request that the appropriate university-level committee(s) consider this proposal.

If you need additional information, please contact this office, or the Department of Biomedical Informatics.

Attachments: proposal and memos of support